International Journal of
Intelligent Systems and Applications in Engineering

ISSN:2147-6799 www.ijisae.org Original Research Paper

A New Real Time Control Approach for Time Efficiency in Group Elevator Control System

Mehmet BAYGIN*[1], Dilbirin ORHAN[2], Orhan YAMAN[3], Mehmet KARAKOSE [3]

Accepted 3rd September 2016

Abstract: In parallel with the increase seen in the number of high-rise buildings, vertical transport systems are progressing. One of the results of this progress is the emergence of group elevator systems and their primary aim is to transport its passengers to the target floor the fastest way possible. Studies on this field are generally simulation and optimization based and they have an aim of minimizing the passengers' waiting and traveling periods. In this study, a real time group elevator experimental setup was created and an optimization algorithm was applied on the setup. Genetic algorithm was chosen as optimization algorithm and this method was tested in an elevator prototype of 10 floors and 5 cabins. The results obtained revealed efficiency, performance and accuracy of proposed method.

Keywords:*group elevator systems, optimization, genetic algorithm, average waiting time, real time control*.

1. Introduction

Elevator systems are of utmost importance in our daily lives. These systems are used in nearly all fields and they provide ease especially in vertical transport [1, 2]. In addition to this, when we take rising number of high-rise buildings of today's world into account, importance of elevator systems increases [3].
In parallel with increasing number of floors in buildings, the population in the buildings also increases and single cabin elevator systems fail to meet the needs of this population [4-6]. Group elevator systems, which have emerged for satisfying this needs, are seen in many buildings and are in active use today. In general sense, group elevator systems are active usage of two or more elevator systems in the same building. Main aim of these systems is to ensure that people's average waiting and traveling period is reduced [5-7].
In one of the studies in line with these objectives, group elevator systems are optimized using genetic algorithms. In the study, a system of 20 floors and 4 cabins were created and reducing people's average waiting and traveling period is aimed. Directional calls were used and these calls were previously uploaded into the system. Obtained simulation results show efficiency of the proposed approach [8]. In another study on the same subject, hybrid optimization technique was proposed. In the study in which particle batch optimization and simulated annealing algorithms are used and a system of 16 floors and 4 cabins was preferred. Average waiting period, long waiting percent and process time was taken into account in the study. Proposed approach overcame the deficiencies of particle batch optimization algorithm and offered a new solution for timing group elevator systems [9].
In another study on group elevator systems, three different optimization techniques were used for process of timing. Genetic algorithm, artificial immune algorithm and DNA algorithm were used in this study and an estimation algorithm was proposed. In simulation processes, a 20 floor and 5 cabin system was considered and approximately 500 directional calls were created. In the system in which all methods are tested in line with these calls, a decrease in people's average waiting periods was observed [10]. In another study for average waiting time, a simulation environment consisting of 16 floors and 4 floors was created. In this study, a numeric keypad was used for people to enter their destination floors. Therefore target floors could be known beforehand. In addition to this, an artificial immune optimization algorithm was used in the study in order to for the cabins to detect the optimal way [11]. In another study on the same field, a fuzzy group elevator control algorithm was proposed. In this study, there are five different control algorithms based on FPGA. An example of block diagram summarizing this structure which consists of four different modules is as seen in Fig. 1 [12].

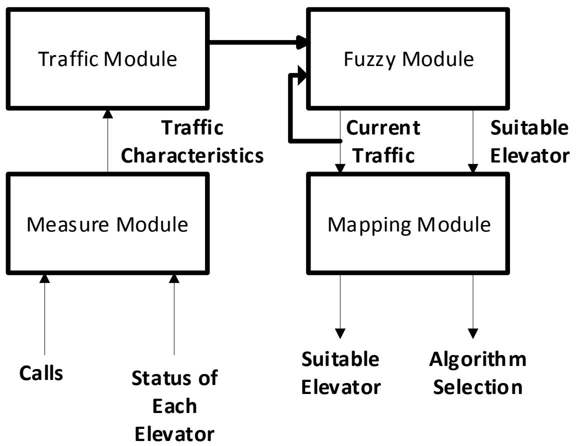

Figure 1. The proposed approach in literature [12]

In another study which proposes a different point of view to analyse group elevators, the aim was to create double cabin elevator systems. In this approach, which was applied on group elevator systems, genetic network programming technique was used and it was revealed that the proposed approach diminished waiting and traveling periods in different building traffics. The block diagram to summarize the system used in this study is given in Fig. 2 [13]. Another issue to take into account in group

[1] *Computer Engineering Department, Firat University, 23119, Elazig/Turkey*
** Corresponding Author:Email: mehmetbaygin@ardahan.edu.tr*
Note: This paper has been presented at the 3rd International Conference on Advanced Technology & Sciences (ICAT'16) held in Konya (Turkey), September 01-03, 2016.

elevator systems is energy efficiency. In another study, in addition to minimizing cabins' average waiting and traveling times, an adaptive control system with the aim of diminishing energy use was proposed. In this approach, genetic algorithm, clonal selection algorithm, DNA algorithm and estimating algorithm was used. Besides, in this system, a fuzzy structure was created to make effective use of these algorithms. The proposed system calculates average waiting and traveling periods and energy amounts to be used by the cabins to detect the optimal solution. An example block diagram of this paper is presented in Fig. 3 [14].

In this study, a genetic algorithm was used for time efficiency optimization of group elevator systems. Within the scope of the study, an experimental setup of 10 floors and 5 cabins was established and optimization algorithm was tested on this system. On the established experimental setup, people could enter their destination floors thanks to numeric keypad. Directional floor call keys were also used. Also, optimization algorithm was applied on both call types and system behaviour was studied. In line with these objectives, details of the optimization algorithm was given in part two. In part three, work patterns of the elevator control system was referred to and in part four, experimental results were included. In the fifth and the last parts of the study, results were presented.

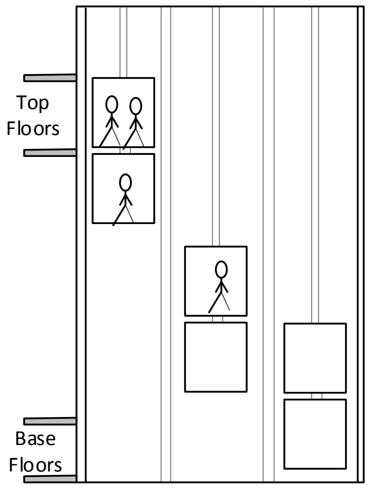

Figure 2. Proposed method in literature [13]

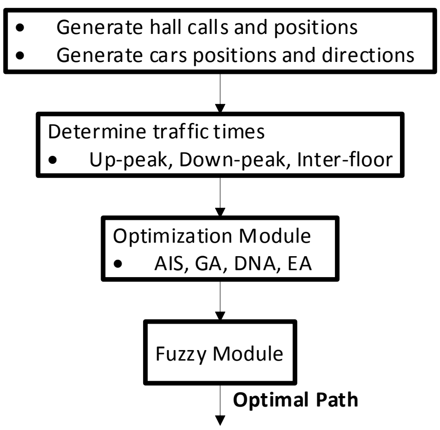

Figure 3. The proposed approach in literature [12]

2. Genetic Algorithm for Elevator Control System

Control and optimization of a group elevator system is an important issue. Using optimization techniques in these systems for usage of elevator cabins ideally and for the elevator to provide its services to the people is a must. In the study performed with this objective, genetic algorithm was used and minimizing people's waiting period was aimed.

Genetic algorithm is an optimization technique which is commonly used in literature and applied in many fields [15, 16]. Pseudo code of this approach which aims best ideal solution in big solution space is shown step by step in Fig. 4.

Genetic Algorithm Pseudo Code

Step 1:	Initial population of randomly generated sequences of binary numbers
Step 2:	A certain amount of element is selected for the solution
Step 3:	Crossing is applied to new population
Step 4:	Mutation process is applied for the same population
Step 5:	Affinity values of elements of these populations are found
Step 6:	2. step is repeated until it reaches the maximum number of transactions

Figure4. Genetic algorithm pseudo code

One of the most important difficulties encountered in organization methods is specifying objective function. Objective function, which is of utmost importance in problem solving, is seen as in Equation 1 for group elevator system.

$$Affinity = (|k - l|) * T_K * a_1 + T_D * a_2 \qquad (1)$$

$k = Elevator's\ floor$

$l = Elevator's\ target\ floor$

$T_K = Elevator's\ average\ passing\ time$
$between\ two\ floors$

$T_D = Elevator's\ door\ openin\ closing\ time$

$a_1 = Equation\ weight\ (0.8)$

$a_2 = Equation\ weight\ (0.2)$

Genetic algorithms are one of the most frequently used optimization techniques. One of the principal reasons for this is that genetic algorithms are able to offer really fast and effective solutions in big solution spaces. Therefore, this method was chosen for the study and used for control and optimization of group elevators.

3. Experimental Results

In order to put the proposed approach into practice, an elevator prototype was developed which worked in line with the real elevators. This system has 10 floors and 5 cabins. Dial calls are designed both as directional and as in a way which destination floor can be entered. For this purpose, a numeric keypad is integrated onto the system. An example block diagram on the designed system can be seen in Fig. 5.

In the designed system there are seven segment displays on each cabin and these displays show the floor the cabin is on. There is also a 2x16 LCD screen placed on top of the system. In this group elevator system of 10 floors and 5 cabins, Can Bus communication standard is used. Communication of the system with the outer world is established with an RS-232 port via serial communication systems. Data is both transferred and read through this network. Various data polls were created on main computer line for measuring performance of the system and these calls are transferred to the processor controlling the elevator. Therefore, performance tests could be made and statistical information could be obtained.

On the system, the tests are made through three different ways. These are elevator control approach using classical directional floor call, elevator control approach based on directional floor call based on optimization and elevator control approach using numeric keypad. The system receives calls from call pool, floor and cabin numbers, cabin position and direction information as an entry. Then it applies the chosen one of the 3 proposed methods onto the system. When this frame is considered, diagram for the proposed approach is as seen in Fig. 6. In addition to this, a block diagram to summarize the way the system works is shown in Fig. 7

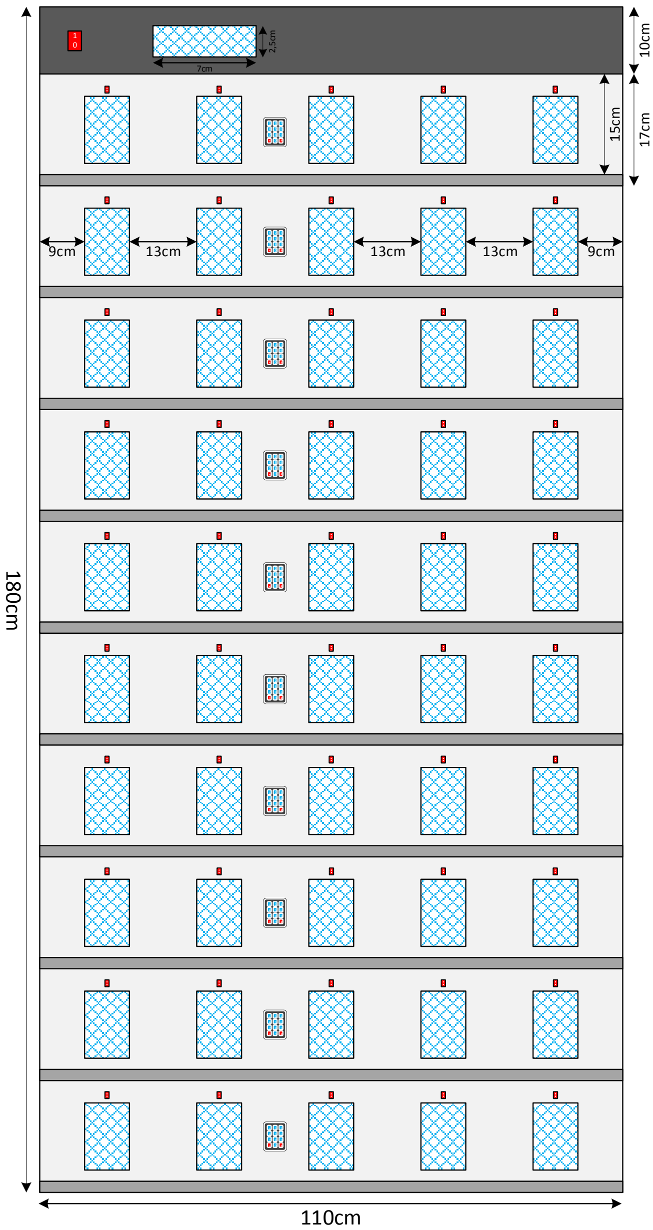

Figure 5. Designed group elevator system

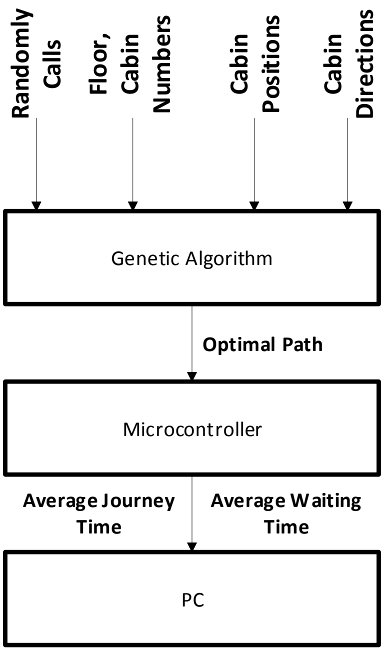

Figure 6. The flowchart of proposed approach

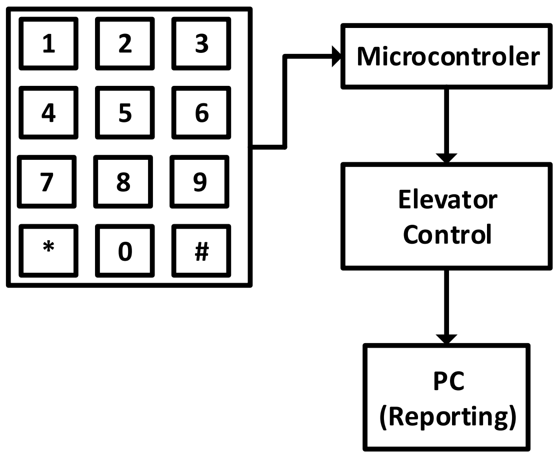

Figure 7. The system with numerical keypad

4. Experimental Results

In this study, group elevator systems' control and optimization were performed. For this purpose, an elevator system of 10 floors and 5 cabins was established and optimization of incoming floor calls was performed using genetic algorithms. With this optimization process, minimizing people's waiting period was aimed. Three different situations were taken into account in tests. First of them is the system using classical methods and directional buttons. In this application, the system works in line with the logic of closest floor. In other words, the cabin which stands closest to the floor from which the call is made is transferred to the floor. In the second scenario, optimization of these directional calls is managed with genetic algorithms. A call pool of random directions and these calls are optimized with genetic algorithm. In the third and last scenario, a numeric keypad integrated onto elevator prototype was used. This allowed people to enter the destination floor they want to be on. The most important advantage of this method is that the capacity to know of destination floors beforehand. An image of experimental setup established within this framework is shown in Fig. 8 and 9.

Figure 8. The experimental setup

Figure 9. The cabins, display and numerical keypad

There are basically three different traffic periods in elevator systems. These are respectively up-peak, down-peak and interfloor. Up-peak is the period which is encountered usually in the mornings, when people are keen to travel upstairs. Down-peak is the period encountered at the end of the shift, when people are keen to travel downstairs. Interfloor traffic is the type of traffic encountered between floors during the day. Interfloor traffic was taken into account in this study. In calls with random directions created in line with this situation, the number of downward and upward calls are approximately the same. Details of the building and the cabins are given on Table 1. In addition, starting locations of cabins are kept fixed and cabins' location and direction information is given on Table 2.

Table 1. Building and elevator features

Element	Values
Number of floors	10
Number of elevators	5
Floor height (cm)	17
Speed (cm/s)	5
Number of calls	500
Number of up direction calls	289
Number of down direction calls	211

Table 2. Floor and direction of cabins

Cabin No	Floor	Directions
1	5	Up
2	9	Down
3	1	Up
4	8	Down
5	6	Up

As reported in the very beginning of the report, three different applications were developed on the system. Random calls created in the beginning phase are tested and system behavior was examined. In this process, average waiting periods were consistently measured and a graphic indicating the results of this change can be seen in Fig. 10.

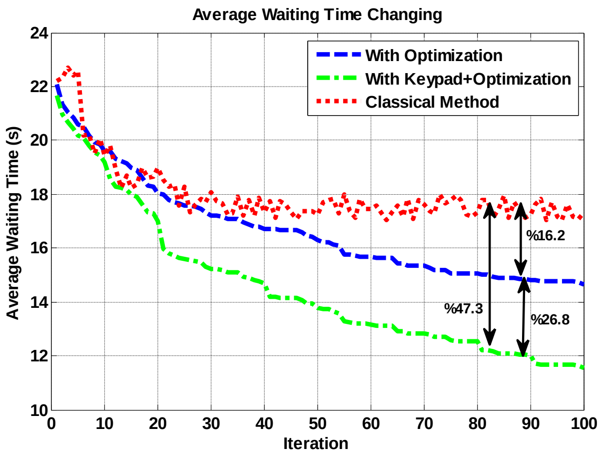

Figure 10. Average waiting times for three different test condition

As it can be seen in Fig. 10, the ideal solution of three different tests turned out to be the one in which numeric keypad and optimization were used together. Besides, classical method offered provided the worst performance. In the light of this data, Table 3 shows average waiting periods and system performance assessment.

Table 3. Floor and direction of cabins

	Classic	Optimization	Keypad
AWT (s)	18.01	16.67	14.54
~CPU (%)	11	63	35

As it can also be seen on Table 3, the systems in which numeric keypads were used turned out 23,8% more efficient, which means these systems provided a 14,6% more performance level when compared to the approach in which the optimization technique is used. When CPU usage data is analysed, the reason that classical method is the most advantageous one is that it steers the cabins according to the closest floor principle. When optimized system and the system with numeric keypad are compared by means of CPU performance, numeric keypad system is on step ahead.

5. Conclusions

Group elevators were optimized with the study's proposed approach. With this objective, a prototype of a group elevator system of 10 floors and 5 cabins was set up and tests progressed on this experimental setup in real time. A numeric keypad system was integrated into the elevator, different from classical elevator systems, and the people were allowed to enter their destination floor before they get on the elevator.

In this approach, genetic algorithm was chosen for the method of organization. This algorithm is fast and efficient, paving the way to its preferability. Three different approaches were taken in testing process. As a result of the studies, the control system with numeric keypad worked better. Thanks to this new approach, a 20% more efficiency could be get and a 14% gain could be managed when compared to the systems in which only optimization techniques were used.

Acknowledgements

This study was supported under the Teknogirisim project of the Ministry of Science, Industry and Technology. Project No: 0648.TGSD.2015. This study is presented in ICAT'16 conference.

References

[1] Fernandez J. R. and Cortes P.A Survey of Elevator Group Control Systems for Vertical Transportation: A Look at Recent Literature, IEEE Control Systems, Vol. 35, No. 4, 2015, pp. 38-55.

[2] Fernandez J., Cortes P., Munuzuri J. and Guadix J. Dynamic Fuzzy Logic Elevator Group Control System With Relative Waiting Time Consideration, IEEE Transactions on Industrial Electronics, Vol. 61, No. 9, 2014, pp. 4912-4919.

[3] Jamaludin J., Rahim N. A. and Hew W. P.An elevator group control system with a self-tuning fuzzy logic group controller, IEEE Transactions on Industrial Electronics, Vol. 57, No. 12, 2010, pp. 4188–4198.

[4] Valdivielso A. and Miyamoto T.Multicar-Elevator group control algorithm for interference prevention and optimal call allocation, IEEE Transactions on Systems, Man and Cybernetics Part A: Systems and Humans, Vol. 41, No. 2, 2011, pp. 311-322.

[5] Utgoff P. E. and Connell M. E.Real-time combinatorial optimization for elevator group dispatching, IEEE Transactions on Systems, Man, and Cybernetics A, Vol. 42, No. 1, 2012, pp. 130–146.

[6] Sun J. Zha Q. C. and Luh P. B. Optimization of group elevator scheduling with advance information, IEEE Transactions on Automation Science and Engineering, Vol. 7, No. 2, 2010, pp. 352–363.

[7] Bolat B. and Cortés P.Genetic and tabu search approaches for optimizing the hall call—car allocation problem in elevator group systems, Applied Soft Computing, Vol. 11, No. 2, 2011, pp. 1792–1800.

[8] Tartan E. O.,Erdem H. and Berkol A.Optimization of waiting and journey time in group elevator system using genetic algorithm, IEEE International Symposium on Innovations in Intelligent Systems and Applications (INISTA) Proceedings, pp. 361-367, Jun. 2014, Alberobello.

[9] Fei L., Xiaocui Z. and Yuge X.A new hybrid elevator group control system scheduling strategy based on Particle Swarm Simulated Annealing Optimization algorithm, 8th World Congress on Intelligent Control and Automation (WCICA), pp. 5121-5124, Jul. 2010, Jinan.

[10] Baygin M. and Karakose M.A New Intelligent Group Elevator Control Approach, in Proceedings of the 15th International Symposium (MECHATRONIKA), pp. 1–6, Dec. 2012, Prague.

[11] Yuge X., Fei L. and Xiaolan L.Hybrid destination registration elevator group control system with artificial immune optimization algorithm, 8th World Congress on Intelligent Control and Automation (WCICA), pp. 5067-5071, Jul. 2010, Jinan.

[12] Munoz D. M., Lianos C. H., Rincon M. A. and Van Els R. H.Distributed approach to group control of elevator systems using fuzzy logic and FPGA implementation of dispatching algorithms, Engineering Applications of Artificial Intelligence, Vol. 21, No. 8, 2008, pp. 1309-1320.

[13] Yu L., Zhou J., Mabu S., Hirasawa K. and Hu J.A Double-deck Elevator Group Supervisory Control System with Destination Floor Guidance System using Genetic Network Programming, SICE-ICASE International Joint Conference, pp. 5989-5994, Oct. 2006, Busan.

[14] Baygin M. and Karakose M.Immunity-Based Optimal Estimation Approach for a New Real Time Group Elevator Dynamic Control Application for Energy and Time Saving, The Scientific World Journal, Vol. 2013, 2013, pp. 1-12.

[15] Karakose M., Baygin M. and Baygin N.An analysis approach for optimization based reconfiguration in photovoltaic arrays, IEEE 23rd International Symposium on Industrial Electronics (ISIE), pp. 954-959, Jun. 2014, Istanbul.

[16] Yetis H., Baygin M. and Karakose M.A New Micro Genetic Algorithm Based Image Stitching Approach in Camera Arrays, The 5th International Conference on Manufacturing Engineering and Process (ICMEP), May. 2016, Istanbul.